“CEMENT MANUFACTURING AND ITS QUALITY”

A Project Work

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CERTIFICATE OF APPROVAL

This project work entitled, "**Cement Manufacturing and its quality**" by Mrs. Ankita Bhandari under the supervision of Mr. Thakur Sedhai, is here submitted for the partial fulfillment of project work of chemistry of grade 12 has been accepted.

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ABSTRACT

Cement is a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cements are finely ground powders that, when mixed with water, set to a hard mass. Setting and hardening result from hydration, which is a chemical combination of the cement compounds with water that yields submicroscopic crystals or a gel-like material with a high surface area. Cement is used in the production of concrete, which is the main ingredient in building almost every building in the world. In 2010, the world production of hydraulic cement was 3,300 megatons ($3{,}600 \times 10^6$ short tons). The top three producers were China with 1,800, India with 220 and USA with 63.5 million tons for a total of over half the world total by the world's three most populated states. As at year-end 2012, the global cement industry consisted of 5673 cement production facilities, including both integrated and grinding, of which 3900 were located in China and 1773 in the rest of the world. Total cement capacity worldwide was recorded at 5245 Mt in 2012, with 2950 Mt located in China and 2295 Mt in the rest of the world. The Cement manufacturing sector plays a vital role in the nation’s economic development since cement is the most versatile and widely used construction material. The cement industry has made phenomenal progress in terms of volume, technology and product up gradation in recent years which is why we will need more cement than ever for developing every country in the world and we will need more efficient and cheap way for it to be transported everywhere.

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INTRODUCTION

Background

The word “cement” can be traced back to the Ancient Roman term opus caementicium, used to describe masonry resembling modern concrete that was made from crushed rock with burnt lime as binder. Cement is a binder, a substance used for construction that sets, hardens, and ad- heres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel (aggregate) together. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete. Concrete is the most widely used material in existence and is behind only water as the planet’s most-consumed resource.[1]

Cements used in construction are usually inorganic, often lime or calcium silicate based, which can be characterized as non-hydraulic or hydraulic respectively, depending on the ability of the cement to set in the presence of water (see hydraulic and non-hydraulic lime plaster).

Cement is an inorganic, non-metallic substance with hydraulic binding properties and is used as a binding agent in building materials. It is a fine powder usually grey in colour that consists of the mixture of the hydraulic cement minerals to which one or more forms of calcium sulphate have been added. Mixed with water it forms a paste, which hardens due to the formation of cement mineral hydrates. Cement is the binding energy in concrete, which is the combination of the cement, mineral aggregates and water. Cement is a key building material for a variety of applications.

Different Types of Cement

There are different types of cement based on different compositions according to spe- cific end uses namely Ordinary Portland Cement, Portland Pozolona Cement, Portland Slag Cement and White Cement. The basic difference lies in the percentage of clinker used.[2]

- Ordinary Portland Cement

Ordinary Portland Cement known as OPC in construction is a type of cement that is manufactured and used worldwide. The Ordinary Portland Cement comprises calcareous and argillaceous materials, such as limestone or chalk, and from alu- minium oxide, silica oxide, ferric oxide, and magnesium oxide found as clay or shale. Ordinary Portland Cement is available in three different grades that are grade 33, grade 43, and grade 53. Its price is 650 to 900 per 50 kg sack in Nepal.

- **Portland Pozolona Cement**

  Another common type of cement in Nepal is PPC cement. When fly ash, volcanic ash, Calcined clay, Lica fumes are added to Ordinary Portland Cement then it be- comes Portland Pozolona Cement. Moreover, adding a grind pozolonic clinker with Portland cement also makes PPC cement. It has a high resistance to different chemical assaults on concrete. PPC's price is 640 to 850 per 50 kg sack in Nepal. PPC Cement is best used in marine structures, sewage works, bridges, piers, dams, mass construction works, and decorative works as well.

- **Portland Slag Cement**

  The next cement type in Nepal is PSC (Portland Slag Cement). It is a blended cement where Slag is, essentially, a non-metallic product comprising more than 90% glass with silicates and alumino-silicates of lime. PSC is created with a combination of up to 45-50% slag, 45% – 50% clinker, and 3-5% gypsum. It is environmentally friendly. Moreover, PSC has a low heat of hydration. PSC cement has a price of Rs. 750 to 800 per 50 kg sack in Nepal.

- **White Cement**

  White Portland cement, or White Cement, or White Ordinary Portland Cement (WOPC) is exactly the same as Ordinary Portland Cement and Portland Pozolona Cement in all ways. The only difference is except its white color. For, obtaining this white color requires a radical change in the way it is made.[3] Thus, because of this, it is more expensive than a gray product. It is manufactured by using raw materials that are free from iron and oxide. White Portland cement needs to have lime and clay in a higher proportion. The price of white cement in Nepal is approximately Rs. 30 to 40 per kg.

OBJECTIVE OF THE STUDY

- To study about “Cement Manufacturing and its quality”.

LITERATURE REVIEW

The first laboratory researches about the behaviour of reinforced-concrete beam-column joints in 1960 was done by American Portland cement society. The result of these re- searches was published in 1967 by Hansen and Conner. In 1982, Ronald, Minhayt and Jirsa as the members of ASCE society, carried out a research about shear strength of reinforced concrete joints. These researchers believed that the existing researches were not adequate to that time to present a value for shear strength of reinforced-concrete connection. In 1983, Ehsani and White published their research about the behaviour of external reinforced concrete under seismic load. In 2003, Pantazopoulou and Bonacci in their analysis studies responded some questions about reinforced concrete joints. These researchers by investigating joints mechanic under lateral loads, proposed spe- cial formulation for the behaviour of joints based on strains, similarity, and stresses equilibrium.[8]

In 1992, Ha et al investigated the response of joints made by high strength concrete against forward and return. The study of the behavior of these joints, development of a new attitude for designing them and investigating the attracted energy in them are the major purposes of this research. In 1992, Tesunus et al studied about the seis- mic behavior of type 2 external joints in which traverse diagonal reinforcement was used in joint core. In 1994, Lou et al in a laboratory research on the joints made with the scale of 1/1, investigated the details of tensile reinforcement in joints of corner of reinforced-concrete frames. In 1994, Cramer and Shahruz investigated the seismic re- sponse of corner joints [8]. In this laboratory study, 4 corner joints were studied. The difference of these joints was in the details of connection execution. Scat is one of the researchers who carried out some studies about joints in 1996 to 2000. In 2004, Nahadi et al published an article about analytic solution to find the relation between cohesion and reinforcement sliding in reinforced concrete joints.

Despite the abundance, domestic cement production only accounts for 40% of total con- sumption in Nepal,informs Tej Kant Jha, general manager, Udayapur Cement Industries (UCI). He adds, ”UCI alone has been fulfilling 25% of the total domestic market de- mand”. All other Nepali cement

manufacturers contribute about 15% of the demand. Imported cement,mainly Indian, fulfil the remaining 60%. But Ramesh Kumar Aryal, general manager, Hetauda Cement Industries (HCI)chooses to differ. He comments, ”In the latest scenario, imported cement supplies 70% of the market demand”.Needless to say, a good market for cement exists within and outside the country. Aryal adds, ”With inadequate infrastructure and frequent power crisis in the industries, forget exporting, even self dependency in cement production will remain a dream”.The data from the De- partment of Industries does confirm that cigarettes and beer are the only merchandise whose total capacity utilisation exceeds 50%.

RESULTS AND DISCUSSION

Through the research conducted regarding the topic, different ideas about the cement industry in Nepal has been gained which helps learn about the presence of different cement manufacturers with accordance to their own specialty. The devastating earth quake on April 2015 marks seven year on the calendar this April. Since the earthquake, a ta total of 37 new cement industries have been registered in the country. According to the Department of Industry, there is a commitment to invest Rupees 180 billion in these in-dustries. The registration of some of these industries have been completed while many industries are in a state of ‘wait and see’.

After the earthquake, the construction work was intensified. Therefore, investors were vying to set up a new cement industry. However, many industries had to back down immediately after the construction work failed to pick up the expected pace.

The supply of cement is almost double than the demand in the context of Nepal. Ac- cording to the Nepal Cement Manufacturers Association, the demand for cement has halved due to the pandemic. Therefore, thought investors have announced for establish- ing industries, they are not much interested in setting up the industry.

The methods of manufacturing of the cement and the steps for its quality control are as discussed below:

Manufacturing of Cement in Industries

Production of cement completes after passing of raw materials from the following six phases. These are;

Raw material extraction

Grinding/Proportioning and Blending

Pre-heater Phase

Kiln Phase

Cooling and Final Grinding

Packing and Shipping

Raw material extraction

Cement uses raw materials that cover calcium, silicon, iron and aluminium. Such raw materials are limestone, clay and sand. Limestone is for calcium. It is com- bined with much smaller proportions of sand and clay. Sand & clay fulfil the need of silicon, iron and aluminium.[5] Generally cement plants are fixed where the quarry of limestone is near bye. This saves the extra fuel cost and makes cement somehow economical. Raw materials are extracted from the quarry and by means of conveyor belt material is transported to the cement plant. There are also various other raw materials used for cement manufacturing. For example shale, fly ash, mill scale and bauxite. These raw materials are directly brought from other sources because of small requirements. Before transportation of raw materials to the cement plant, large size rocks are crushed into smaller size rocks

with the help of crusher at quarry. Crusher reduces the size of large rocks to the size of gravels.

Grinding/Proportioning and Blending

The raw materials from quarry are now routed in plant laboratory where, they are analyzed and proper proportioning of limestone and clay are making possible before the beginning of grinding. Generally, limestone is 80% and remaining 20% is the clay. Now cement plant grind the raw mix with the help of heavy wheel type rollers and rotating table. Rotating table rotates continuously under the roller and brought the raw mix in contact with the roller. Roller crushes the material to a fine powder and finishes the job. Raw mix is stored in a pre-homogenization pile after grinding raw mix to fine powder.

Pre-heater Phase

After final grinding, the material is ready to face the pre-heating chamber. Pre- heater chamber consists of series of vertical cyclone from where the raw material passes before facing the kiln. Pre-heating chamber utilizes the emitting hot gases from kiln. Pre-heating of the material saves the energy and make plant environ- mental friendly.

Kiln Phase

Kiln is a huge rotating furnace also called as the heart of cement making process. Here, raw material is heated up to 1450 °C. This temperature begins a chemical reaction so called decarbonation. In this reaction material (like limestone) re- leases the carbon dioxide. High temperature of kiln makes slurry of the material. The series of chemical reactions between calcium and silicon dioxide compounds form the primary constituents of cement i.e., calcium silicate. Kiln is heating up from the exit side by the use of natural gas and coal. When material reaches the lower part of the kiln, it forms the shape of clinker.

Cooling and Final Grinding

After passing out from the kiln, clinkers are cooled by mean of forced air. Clinker released the absorb heat and cool down to lower temperature.

Released heat by clinker is reused by recirculating it back to the kiln. This too saves energy. Final process of 5th phase is the final grinding. There is a horizontal filled with steel balls. Clinker reach in this rotating drum after cooling. Here, steel balls tumble and crush the clinker into a very fine powder. This fine powder is considered as cement. During grinding gypsum is also added to the mix in small percentage that controls the setting of cement.

Packing and Shipping

Material is directly conveyed to the silos (silos are the large storage tanks of cement) from the grinding mills. Further, it is packed to about 20-40 kg bags. Only a small percent of cement is packed in the bags only for those customers whom need is very small. The remaining cement is shipped in bulk quantities by mean of trucks, rails or ships.

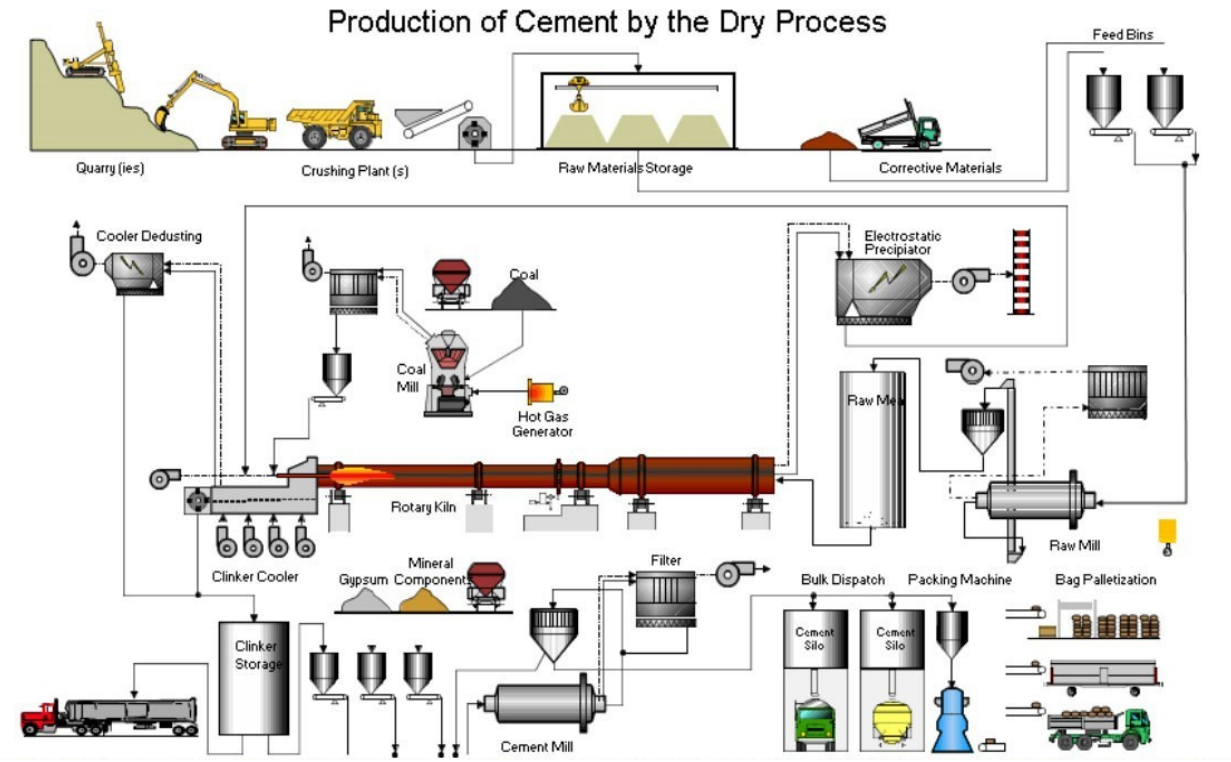

Figure 1: Manufacturing process of cement

Quality Control of Cement

“Quality Tests on cement are carried out to check the strength and quality of the cement used in construction. It helps to identify the usage of cement for different purposes based on its durability and performance.”

Quality control of the slurry in the cement industry is based on weight ratio control of raw materials. Raw materials composition is usually assumed constant and know due to difficulties in direct measurement. In this case study a raw materials mill control developed and implemented in a factory is presented.

To produce high-quality cement, the mineralogical and chemical composition of raw materials as well as intermediate and finished products has to be

determined. At each stage of the production, samples have to be taken, processed and analysed to ensure quality control without gaps.[5]

Quality of cement is ascertained by making compressive strength tests on cement cubes. However for effective control cement,the cement:

Should be tested initially once for each source and subsequently once for every two months

Should be protected from moisture

Should be retested after 3 months of storage, if long storage in unavoidable

Should be rejected if large lump are found in cement bags.[6]

The following tests are conducted on cement in the laboratory are as follows:

Fineness Test

The fineness of cement is responsible for the rate of hydration, rate of evolution of heat and the rate of gain of strength. Finer the grains more is the surface area and faster the development of strength.

The fineness of cement can be determined by Sieve Test or Air Permeability test.[7]

Sieve Test:

Air-set lumps are broken, and the cement is sieved continuously in a circular and vertical motion for a period of 15 minutes. The residue left on the sieve is weighed, and it should not exceed 10% for ordinary cement. This test is rarely used for fineness.

Air Permeability Test:

Blaine’s Air Permeability Test is used to find the specific surface, which is expressed as the total surface area in sq.cm/g. of cement. The surface area is more for finer particles.

Consistency Test

This test is conducted to find the setting times of cement using a standard consis- tency test apparatus, Vicat’s apparatus.

Standard consistency of cement paste is defined as that water content which will permit a Vicat plunger of 10 mm diameter and 50 mm length to penetrate depths of 33-35 mm within 3-5 minutes of mixing.

The test has to undergo three times, each time the cement is mixed with water varying from 24 to 27% of the weight of cement.This test should be conducted at a constant temperature of 25°C or 29°C and at a constant humidity of 20%.

Setting Time Test

Vicat’s apparatus is used to find the setting times of cement i.e., initial setting time and final setting time.

Initial Setting Time:

For this test, a needle of 1 mm square size is used. The needle is allowed to penetrate into the paste (a mixture of water and cement as per the consistency test). The time taken to penetrate 33-35 mm depth is recorded as the initial setting time.

Final Setting Time:

After the paste has attained hardness, the needle does not penetrate the paste more than 0.5 mm. The time at which the needle does not penetrate more than 0.5 mm is taken as the final setting time.

Strength Test

The strength of cement cannot be defined directly on the cement. Instead the strength of cement is indirectly defined on cement-mortar of 1:3. The compres- sive strength of this mortar is the strength of cement at a specific period.

Soundness Test

This test is conducted in Le Chatelier's apparatus to detect the presence of un- combined lime and magnesia in cement.

Heat of Hydration Test

During the hydration of cement, heat is produced due to chemical reactions. This heat may raise the temperature of concrete to a high temperature of 50°C. To avoid these, in large scale constructions low-heat cement has to be used.

This test is carried out using a calorimeter adopting the principle of determining heat gain. It is concluded that Low-heat cement should not generate 65 calories per gram of cement in 7 days and 75 calories per gram of cement in 28 days.

Tensile Strength Test

This test is carried out using a cement-mortar briquette in a tensile testing ma- chine. A 1:3 cement-sand mortar with the water content of 8% is mixed and moulded into a briquette in the mould.

This mixture is cured for 24 hours at a temperature of 25°C or 29°C and in an at- mosphere at 90% relative humidity.The average strength for six briquettes tested after 3 and 7 days is recorded.

Chemical Composition Test

Different tests are conducted to determine the amount of various constituents of cement. The requirements are based on IS: 269-1998, is as follows:

The ratio of the percentage of alumina to that of iron oxide should not be less than 0.66.

Lime Saturation Factor (LSF), i.e., the ratio of

the percentage to that of alumina, iron oxide and silica should not be less than 0.66 and not be greater than 1.02.

Total loss on ignition should not be greater than 4%.

Total sulphur content should not be greater than 2.75%.

Weight of insoluble residue should not be greater than 1.50%.

Weight of magnesia should not be greater than 5%.

CONCLUSION

This study provided the basic information about the materials used in the construction sites with the major topic as cement. The report provided the substantial data about the different methods of manufacture of cement and the common ways of quality control prevailing in the industries. After the massive destruction of the households and infrastructures because of the earthquake that occurred in 2015, the supply and demand of cement is almost doubled. With that the number of the manufactures of the cement in the country has also been increasing and the import has as well been increasing.It is seen that cement industry in Nepal has a very bright future and we have the re- sources. Yes, we have limestone mines of cement grade all over the country. As per the Department of Mines and Geology, Nepal has limestone over 7000 sq.km of area. With proximity to two largest economies of the world, the cement industry in Nepal will surely boom exponentially.

SUGGESTIONS FOR FURTHER RESEARCH

For more information about the cement manufacturing and the quality control of the cement, different journals and articles can be accessed. This is the insufficient paper for the information about manufacturing methods of cement and the ways of quality control that are in use for the respective manufacturers. This report gives a brief view about the production of cement and its quality checking in the industries with a mindset of helping the researchers to obtain the simple information about it respectively.

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